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THE STRUCTURE AND ACTION OF A BUTTERFLY'S TRUNK.

BY EDWARD BURGESS.

EVERY one knows that butterflies and moths, the insects forming the group Lepidoptera, often feed on honey, and that for the purpose of obtaining it, they are provided with a long trunk, or tongue as it is sometimes called, to reach the nectaries of flowers. Sometimes this trunk is very long, in the case of our common tomato caterpillar moth, for example, its length is three inches, while in some allied moths of tropical regions it is greatly longer, and botanists and entomologists have often pointed out the relation existing between the length of various long-tubed flowers and of the trunks of some species of moths in the same region.

Thanks to the acuteness of Savigny, entomologists have long known that this trunk is not an organ *sui generis*, but simply the metamorphosed *maxillæ*, or second pair of jaws of biting insects, which have become specialized to form a sucking tube. The mandibles or first pair of jaws, which, while the insect was in the caterpillar stage were well developed to bite off pieces of leaves or other substances then its food, are, in the perfect butterfly, reduced to the merest rudiments (Fig. 1, *md*), only to be found by carefully brushing away the thick covering of scales and hairs. The pair of maxillæ, on the contrary, grow each into a long, gently-tapering organ with a deep groove along its inner surface; which surface being applied to that of the opposite maxilla, and held in this position by a sort of dove-tailing lock, there is formed a hollow trunk through which liquid food can be drawn into the mouth.

When not in use the trunk is coiled into a close spiral, and lies beneath the insect's head, hidden between the large and hairy feelers of the lower lip—the labial palpi—which are specially developed for this service.

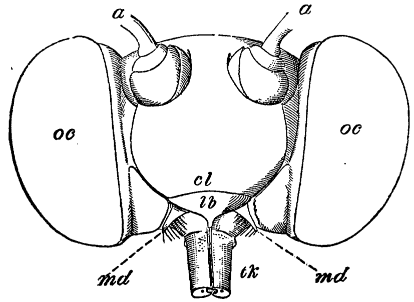

FIG. 1.—Face of *D. archippus*; *oc*, compound eyes; *a*, antennæ; *cl*, clypeus, *lb*, labrum or upper lip; *md*, the small mandibles armed on the inner edge with stiff bristles; *tk*, base of the trunk.

Now although, as just said, these facts have long been known, the mechanism for sucking liquids through the trunk seems never to have been noticed, and it has been supposed that the power of suction lay in the "sucking stomach," so called, or perhaps in the peristaltic contraction of the trunk, or that simply the capillary action of the latter might be sufficiently powerful to dispense with any special sucking apparatus. The anatomy of the trunk has been equally neglected and misunderstood. Thus even Burmeister believed that each half had a canal of its own, and Newport described non-existing horizontal muscles, and otherwise mistook the muscular mechanism.

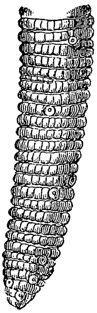

FIG. 2.—Tip of trunk of *D. archippus* from outside, greatly magnified. The rings are really black and opaque, the intervening spaces delicate and transparent.

Having been for some time engaged in studying the anatomy of the "emperor," as Mr. Scudder has christened *Danais archippus*, our largest and very common butterfly, I will describe the mouth organs of this species, the same plan of structure prevailing through the whole group of Lepidoptera, at least wherever I have examined representatives.

In the "emperor" then, the trunk is about fifteen millimeters long, with a width at the base of about ⅔ mm., from which it gradually tapers to a point at the tip. Externally a sort of coat-of-mail appearance is given by its composition of an immense number of rings (Fig. 2) (or rather portions of rings, the inner segments being of course wanting) which being united by more yielding parts of the cuticle, evidently permit the rolling up of the whole organ, while imparting at the same time the necessary stiffness. The rings are not perfectly regular, but vary in width and are here and there broken, or branch and anastomose.

Figure 2 shows a few of their irregularities, but they are less apparent at the tip than higher up. With a strong magnifying power the rings are seen to be made up of little plates[1] soldered together, except on the front surface near the inner edge of the maxilla, where the plates become separated and more or less hexagonal. Dotted over the whole surface, but more thickly at the tip, are seen little circular plates with a minute transparent papilla in the center. These are believed to be metamorphosed hairs, and in some butterflies and moths become greatly and peculiarly developed,[2] and are supposed by Fritz Müller to be organs of the sense of taste or touch, perhaps both. Breitenbach, however, thinks they play the part of teeth on a saw or file, and serve to tear the delicate flower tissues for obtaining the sweet juices contained in them. In the famous orange-sucking moth (*Ophideres fullonica*), which sometimes greatly damages the orange harvests, Mr. Francis Darwin[3] has described the remarkable armature at the tip of the trunk, which enables the moth to pierce even the thick skin of an orange, and one set of the curious spines in this case are simply our small papillæ much developed and specialized. These

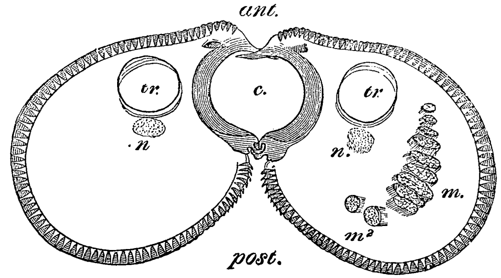

Fig. 3.—Transverse section of trunk showing the two maxillæ united by the dove-tail joint, and forming the interior canal, *c;* the air tubes, *tr;* *n*, nerve; *m* and *m*², the two sets of muscles, probably more or less displaced in the cutting; these are omitted in the left maxilla.

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[1] By examining Figs. 3 and 4 it will be evident that these plates are the bases of little pyramid-shaped bodies (in some regions more like stout nails or tacks) which are imbedded in, or rather specialized portions of, the cuticle. Three of these are shown in the annexed figure, 3 *B*, where *cu* is the cuticle, plainly laminated, and *hy* the underlying matrix or *hypoderm*. It is not improbable that each pyramid corresponds to a single cell of the hypoderm.

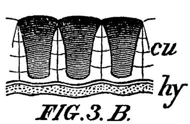

FIG. 3. B.

[2] See papers by Breitenbach in Katter's Entomol. Nachr., v, 238, and in the Arch. Mikros. Anat., xv, 8 and xvi, 308.

[3] *Quart. Jour. Micr. Sci.*, xv, 385.

hair structures in the emperor, however, are not prominent enough, one would think, for mechanical action, and in this and similar cases, their function is probably wholly that of touch or taste. This view is strengthened by their occurrence also *within* the tube, where they appear, but in lesser numbers.

If we imbed the trunk in a mass of paraffine or soap,[1] and cut some thin transverse sections, we shall obtain with the microscope a view of its structure as seen in Fig. 3. Each half of the trunk, that is, each maxilla—has a sort of moon-shaped section, the lower horn of which is snugly dovetailed to the lower horn of the opposite half, while the upper horns are drawn out into long processes, which simply interlace like the fingers of one hand with the other. There is thus inclosed a central canal open from base to tip of the trunk, and its walls are made up of broad but thin, semicircular plates, whose narrow edges give the canal wall, seen from the side, much the appearance of a large trachea, or air-tube (Fig. 4, *c*). Each half of the trunk also contains a real air-tube (*tr*, Figs. 3 and 4), a nerve (*n*) and two sets of muscles (m^1 and m^2), while the rest of the space is filled out with connective tissues.

It has generally been believed[2] that the trunk is extended by muscular action, being rolled up in repose by its own elasticity, like a watch-spring, but the trunk muscles seem, at first sight, to be arranged for just the opposite state of things. They are grouped in two sets in each half of the trunk, each set arising on the anterior surface, and proceeding diagonally downward and backward to be inserted on the posterior surface. They converge too, in this course, so that, viewed from in front, the two sets of muscles form a series of V's one above the other. One of the sets is seen in the vertical section of the right maxilla (Fig. 4), and if we examine this

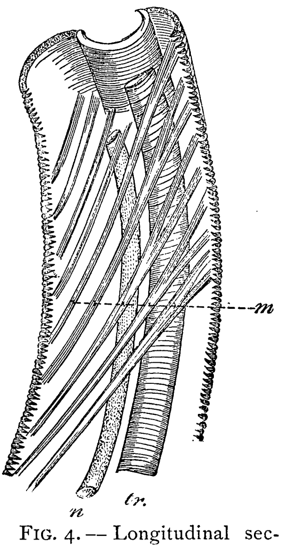

FIG. 4. — Longitudinal section of trunk; the canal, *c*, is shown above; lower down the trachea, *tr*, and the nerve, *n*; while the diagonal muscles, *m*, overlie them. These are spaced somewhat wider than in nature, for the sake of clearness. The right edge is the outer one.[3]

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[1] See directions given by Dr. C. S. Minot in the NATURALIST for April, 1877.

[2] This is the statement of the latest text-book, that of Graber, die Insecten, I, 156.

[3] The cross sections of the rings forming the edges of the figure are engraved as much too irregular. The inner boundary of the cuticle is also omitted.

figure, it would seem that by the contraction of the muscles, the posterior side of the trunk is pulled upwards, and of course shortened, and the shortening taking place along the whole side, the result would be the spiral rolling up of the trunk, with the posterior side within the coil. These diagonal muscles are the only ones to be found, and Newport certainly errs in speaking of annular muscles. On the view of the muscular action just taken, it is evident that the trunk must be unrolled and extended by its own elasticity, and not the reverse, a theory which is certainly very questionable, but at present I am unable to offer a better, and must leave the point to the decision of future investigators. Certainly no writer I have found has thrown the least light upon the subject, or even given a correct general description of the muscular arrangement.

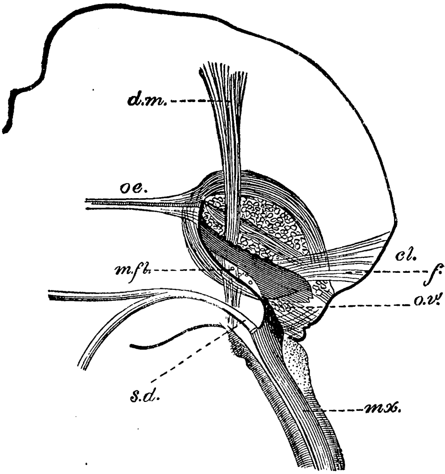

FIG. 5—Longitudinal section through the head giving a view of the interior of the left half; *mx*, the left maxilla whose canal leads into the mouth cavity; *m fl*, floor of the latter showing some of the papillæ of taste; *oe*, œsophagus; *cl*, clypeus; *ov*, oral valve; *sd*, salivary duct; *dm* and *fm*, a dorsal and the frontal muscles which hold the oral sack in its position.

At the base of the trunk large muscular bands run into it from the head in a diagonally opposite direction to the trunk muscles, and are inserted on the anterior surface. Their contraction of course pulls the whole trunk-coil closely up under the head.

Following now the trunk canal upwards into the interior of the butterfly's head, we find (Fig. 5) that it ends in what we may here call a mouth cavity, which is laterally expanded, but has no great diameter from front to back, that is, from palate to floor. The mouth cavity lies in a muscular sack (Fig. 6, seen from above), which is suspended within the head by five muscles, a lateral pair (*lm*), a dorsal pair (*dm*) and one frontal (*fm*). This oral sack is composed of muscular fibres running in a variety of directions as will be seen in Fig. 5; Fig. 6 shows the exterior appearance of the organ and its suspending muscles; the slender œsophagus (*oe*) is seen entering it from above and behind. From the palate, just above the origin of the trunk, projects a triangular muscular flap, which we may call the oral valve (Fig. 5, *ov*) as it serves to close the mouth.

The floor of the mouth is made of a thick chitinized crust, with a longitudinal furrow between two convex regions; the floor thus somewhat resembles in shape the human breast. Each convexity is dotted over with minute transparent papillæ, which are, in general, similar to the papillæ already described, on the surface of the trunk. It seems highly natural to regard the papillæ, in this situation at least, as taste organs, but I have not succeeded in recognizing their nervous connection.

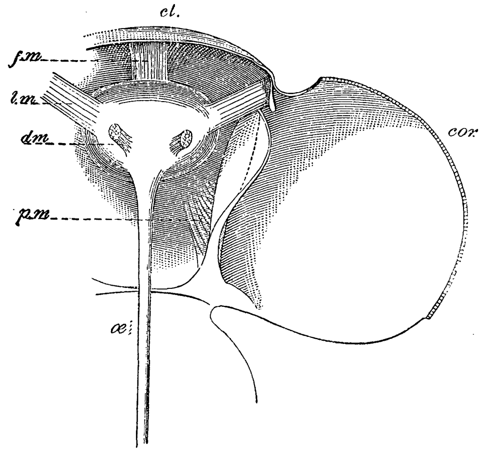

FIG. 6.—Interior view of the bottom of the head, the top having been cut away, showing in the middle the oral sack hung by its five muscles—the frontal, *fm*, the dorsal pair, *dm*, and the lateral pair, *lm; cl*, clypeus; *cor*, cornea of the compound eye (the left eye is not drawn); *oe*, œsophagus; *pm*, one of the large muscles which move the labial palp.

The palate of the mouth, unlike the floor, is lined with a delicate membrane. The suspensory muscles of the oral sack pierce the muscular wall of the latter and reach the palatal membrane. Their contraction would evidently draw the palate away from the floor of the mouth, thus enlarging its cavity. At the base of the trunk, on its lower surface, the common duct (*s d*) of the two lateral salivary glands opens as is shown in Fig. 5.

From the anatomy of these parts we may understand that the butterfly obtains its food in the following manner: The trunk is unrolled and inserted in the nectary of a flower; at this moment the muscles which suspend the oral sack contract, and the mouth cavity is thus extended, creating a vacuum which must be supplied by a flow of honey through the trunk into the mouth. When the mouth is full the muscular sack contracts, the oral valve closes the aperture to the trunk and the honey is forced backward into the œsophagus. The mouth cavity is then again opened and the same process repeated. To prevent the food being sucked back from the œsophagus, it is probable that some of the numerous fibres in the muscular sack near the origin of the former can, by contraction, close its opening, but in any case as the trunk presents a free tube, and the œsophagus leads into the closed alimentary canal, it is evident that the former offers the easiest route for a supply to fill the mouth vacuum.

In the muscular mouth sack, we have thus a pumping organ, of action too simple to be misunderstood. As for the so-called "sucking stomach," its delicate membranous structure is certainly not adapted for sucking functions, and it probably serves only as a reservoir. It is usually found to contain nothing else than air, but Newport asserts that immediately after feeding food is also found in it.

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THE CRITICS OF EVOLUTION.

BY J. S. LIPPINCOTT.

THERE is a large class of minds even among those who esteem themselves educated, who have no acquaintance with science and another, perhaps equally large, who have no idea of what is meant by the scientific spirit. These all imagine, perhaps, that the world of things or phenomena around them, has ever been pretty much as it now appears to the superficial gaze, and that men have always known about as much about the earth, its origin, development and productions, as they now know. They appear to be unconscious of the fact that a century ago we knew almost nothing of the constitution of matter, and were holding the same crude and puerile ideas about nature that were held by the ancients 3000 years ago. They do not seem to be aware that but few conquests, from the domain of the unknown had been made in physical astronomy, and that almost all our knowledge of the composition of the earth and its myriads products, animal, vegetable and mineral, have not yet been reached.

A century ago the simplest phenomena were inexplicable ; no